DOCUMENT RESUME

ED 265 841 IR 011 965

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TITLE	Very Large Scale Integration (VLSI).
PUB DATE	[82]
NOTE	14p.; Papers presented at an Honors Seminar in the Graduate School of Library & Information Science, University of Washington (Seattle, WA).
PUB TYPE	Viewpoints (120) -- Reports - Descriptive (141) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Cybernetics; Designers; Electrical Systems; Electric Circuits; *Futures (of Society); Man Machine Systems; Microcomputers; *Production Techniques; *Social Values; *Technological Advancement
IDENTIFIERS	*Computer Chips

ABSTRACT

Very Large Scale Integration (VLSI), the state-of-the-art production techniques for computer chips, promises such powerful, inexpensive computing that, in the future, people will be able to communicate with computer devices in natural language or even speech. However, before full-scale VLSI implementation can occur, certain salient factors must be addressed: quicker circuitry, lithography for greater bit density, spare memory elements, military needs, computer aided design, combined chip and system design, the engineering education crisis, and the nature of designers and their work. The cost of this technology in human terms must also be considered. While more intelligent machines may intensify production, they may also put skilled people out of work and increase the demand for clerical workers, leading to a devaluation of human resources. In addition, the immediate application of research funds for computer technology may not address quality of life improvement; mass destruction is also a potential result of technological advancement. The conflict is not humans versus the machine; only the way the machine is used can bring about change. (JB)

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VERY LARGE SCALE INTEGRATION

(VLSI)

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VERY LARGE SCALE INTEGRATION

(VLSI)

Abstract

This essay deals with VLSI, the state-of-the-art production techniques for computer chips.

VLSI methods promise such powerful, inexpensive computing people will be able to communicate with computer devices in nearly natural language or even speech.

The first section outlines eight main technical points on which realizing full-scale VLSI depends.

The second section looks at the social management of VLSI technology and asks what the cost of this technology is in human terms.

VLSI TECHNIQUE

In the last ten years there have been improvements in the technology for creating integrated circuit chips. In the early to mid 1970s, 300 - 3000 logic gates could be placed on a chip. The process was designated Large Scale Integration (LSI). LSI random access memory (RAM) chips contained 4, 8 and 16 K-bits. In the late 1970s, Very Large Scale Integration (VLSI) was first realized with the appearance of 64 K-bit RAM chips. While LSI chips have great processing capacity, VLSI chips have greater power and are capable of decreasing the sophistication required of users. The complexity which VLSI allows removes the need for software to integrate or boot up systems. Simplified software will accept near-natural language commands from users. Therefore, VLSI's impact is in making the operation of computers and computer-related devices easier. Increased user-friendliness and lower cost will contribute to making computers pervasive.

Projections for VLSI chips stress increasingly faster operation and denser data capacity, but expectations for improved production technology have not been fully met. Recently forecasts have become more conservative. Slower growth rate predictions suggest 2^{24} logic gates per chip being reached in 1985, although manufacturing expenses will continue to fall (Barbe, 1980). These salient factors affect the feasibilty of future advances: quicker circuitry, lithography, spare memory elements, military needs, computer aided design, combined chip

and system design, the engineering education crisis and the nature of designers and their work.

Quicker Circuitry

Planar silicon technology cannot meet the growing demand of digital, video and radar communication for gigabit-per-second circuits. The higher electron mobility of gallium arsenide (GaAs) provides superiority where speed is vital at any cost. The limit of silicon technology is 1,000 Mb/s. GaAs has the forecast data rate of 2,000 Mb/s by 1985 (Hodges, 1977; Bernhard, 1980).

Lithography for Greater Bit Density

A sub-micrometer gate-length is essential to the further elaboration of VLSI: by putting more logic on each chip (Bernhard, 1982). The gate-length imposed by photo-etching lithographic techniques has been limited to two or three micrometers. Electron-beam lithography, once only used for making masks, now allows direct writing in microwave transistors and custom logic and memory chips. Hewlett-Packard has produced a new system competitive with optical methods. The beam spot for writing pixels has a diameter which can be varied from 0.5 to 0.25 micrometers. The blanking speed is over 300 MHz which means many writing operations can be performed in a short time. Due to using electrons, diffraction does not limit resolution (Eidson,1981). Similarly, Bell Labs have developed an X-ray system which uses 4.36 angstrom wavelength radiation. It produces useful resolution at 0.25 micrometers and is extremely cost-effective (Lepsetter, 1981).

Spare Memory Elements

Bell also created the fault-tolerant circuit to rectify the many chips judged defective and thrown out by manufacturing control (Bernhard, 1980). A laser disconnects drives to defective rows and columns by burning holes in the polysilicon lines under the phosphorus-doped glass. At the same time, replacement rows and columns on the same chip are programmed. The improved chip yields brought about by redundancy features increase the economic possibility of a 256-kb chip despite immature design (Bernhard, 1981).

Military Needs

Improved designs largely depend on the availability of research funds at the federal level. The research direction is determined by the Department of Defense who want very high speed integrated circuits (VHSIC) for running missiles, aircraft, submarines, spacecraft and so on (Barbe, 1980; Einspruch, 1981; Sumney, 1980). The current emphasis is on monolithic devices: complete computers on a chip.

Computer Aided Design

Human ability to meet VLSI needs are being increased through the use of one generation of chips to build the tools for creating the next generation. Although the general idea dates back to the 1950s, computer aided design (CAD) is the most important new tool. CAD shortens the design time for custom chips and allows higher functional density than gate arrays because less subsystems are required.

Combined Chip and System Design

The task and status of integrated circuit designing has changed, too. Chip designers are the new prima donnas of the computer industry. The Mead-Conway method, developed at Cal-Tech and Xerox, combines the roles of chip and system designers (Bernhard, 1982). More efficient logic structures are directly implemented into silicon by top-down design. Physical implementation is determined simultaneously with logic. The intention is to maximize vertical communication between hierarchical functions and minimize horizontal communication between modules: connected functions will be adjacent.

The Engineering Education Crisis

Much VLSI research comes out of major universities--especially Stanford (Mason, 1980). However, IEEE Spectrum does not hide the overall dismal state of electronic engineering education. American university laboratories were fitted out in the 1960s. Many graduates are ill-prepared, having learned design logic for tube computers. Not only does higher education lack money to replace primitive equipment but the faculty positions are low-paying compared to what industry offers. While professors of 10 to 15 years carry out much stipended consulting, there is little to attract new faculty of any quality (Perry, 1981). Over 10% of faculty positions are unfilled and there is a shortage of graduates (Kahne, 1981).

Nature of Designers and Their Work

Another human factor is designers, in general, burning out in reaction to job pressures. Tracy Kidder's The Soul of a New Machine (1981) describes borderline mental health as commonplace. The hiring of enthusiastic but asocial young men is emphasized. Employment listings asking for three to five years experience often mean no more than five years. By their thirties, most designers either move out of the industry or up into administration. The lucky few start and succeed in their own businesses. Physicists are the entrepreneurs at the heart of 20th century economics (Jacobs, 1982).

HUMAN COST OF VLSI

It is appropriate at this point to return to the user-friendly statement mentioned at the beginning. Fresh light will be thrown on this aspect of VLSI by the following comparison.

Two kinds of intelligence are known to exist in the universe: the organic intelligence of people and the inorganic intelligence of their machines. Humans are based on carbon and artificial intelligence (AI) on silicon. Human information processing is characterized by three strikingly different modes. The first is consciousness or attention to solving a particular problem or set of problems. The second is automatic processing such as combing hair and finding the way home. The third is access to long term memory: Pythagoras' theorem and my most embarassing moment as a teenager. Memories may not be

volitionally destroyed except in peripheral storage media: the generic books which compensate for the extremely high-powered form of editing called forgetting.

With the exception of not remembering, AI is similarly structured. Files may not be volitionally purged. Much data is stored externally to the system by charge coupled devices (CCD), magnetic bubbles, disks or tapes. Working memory is devoted to running the system and solving problems so Central Processing Units (CPUs) appear analogous to consciousness. They perform the job of a homunculus librarian by finding the data store and then functioning as the book itself. This is where VLSI shows vigor. More complex hardware needs simpler software and asks less of users.

Drawing such parallels compresses our ideas about people more than those about thinking machines. Deductive, top-down tree structure is only one kind of logic. Not everyone thinks that way. Intelligent machines intensify production by putting classes of people out of work and lower skills are required of clerical workers leading to lower human value. Melville's Bartleby the Scrivner is a woman sitting at an Ethernet or Wangnet word processor. The engineers who build computers are not typical of the population. The reasons they build them are not the same reasons the users have for using them. Electronic engineering as applied physics is big business. Designers work for corporations who want to become richer. The immediate application of government research funds for computer technology is not in making people's lives easier by intensifying production

and advancing knowledge but in increasing military aggressive power. The forces creating the technology for global communication and unity intend to use that technology for mass destruction. Science is never neutral (Rose & Rose, 1980).

Because the goal of VLSI technology is to drive user-friendly into hyperbole as user-irresistible for the PacMan mentality, we are left with the question: Who is endeavoring to control whom? The conflict is not humans versus the machine: a communication medium does not bring about change (Graff, 1982). Only the way it is used can do that.

ELECTRONIC TECHNIQUES OF DATA STORAGE: LSI, VLSI, etc.

LIBR 518--Electronic Information Systems

Andrew Yeaman

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Quotations

> Electronics is not essential to information technology; it bears the same relation to information that electricity bears to power--electronics is a convenient, but not unique, method of representation. It is expected, however, that over the next twenty-five years, almost all the important developments in information technology will be based on electronic techniques.
>
> Barron & Curnow, p.13

> Counting counting they wer all the time. They had iron then and big fire they had towns of parpety. They had machines et numbers up. They fed them numbers and they fractiont out the Power of things. They had the Nos. of the rain bow and the Power of the air all workit out with counting which is how they got boats in the air and picters on the wind. Counting clevverness is what it wer.
>
> Hoban, p. 19

Quotations continued

Thirteen constructs of mind-like systems:

1. Behave as an (almost) arbitrary function of the environment (universality).
2. Operate in real time.
3. Exhibit rational, i.e. effective adaptive behavior.
4. Use vast amounts of knowledge about the environment.
5. Behave robustly in the face of error, the unexpected and unknowns.
6. Use symbols (and abstractions).
7. Use (natural) language.
8. Exhibit self-awareness and a sense of self.
9. Learn from its environment.
10. Acquire its capabilities through development
11. Arise through evolution.
12. Be realizable within the brain as a physical system.
13. Be realizable (itself) as a physical system.

Newell, 1981

I think, therefore I am--except when the system crashes.

Anonymous